DRAFT

Magnetospheric Multiscale (MMS) Project

Fill and Drain Valves Specification

Effective Date: TBD

National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

CM FOREWARD

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In this document, a requirement is identified by "**shall**," a good practice by "should," permission by "may" or "can," expectation by "will," and descriptive material by "is."

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CHANGE HISTORY LOG

Revision Level	DESCRIPTION OF CHANGE	CCR / SCoRe No.	DATE APPROVED
-	Initial Release	CCR-0139	TBD

List of TBDs/TBRs

Item No.	Location	Summary	Ind./Org.	Due Date
1				

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1.0 INTRODUCTION

1.1 GENERAL INFORMATION

The Magnetospheric Multiscale (MMS) mission is the fourth mission of the Solar Terrestrial Probe (STP) program of the National Aeronautics and Space Administration (NASA). The MMS mission will use four identically instrumented observatories/spacecrafts to perform the first definitive study of magnetic reconnection in space and will test critical hypotheses about reconnection. Magnetic reconnection is the primary process by which energy is transferred from the solar wind to the Earth's magnetosphere and is also fundamental to the explosive release of energy during substorms and solar flares.

The MMS mission will study magnetic reconnection in the Earth's magnetosphere. The four MMS observatories will be required to fly in a tetrahedral formation in order to unambiguously determine the orientation of the magnetic reconnection layer.

1.2 SCOPE

This specification describes the performance, physical, and environmental requirements for space-qualified *Propulsion Subsystem Gas Fill and Drain Valves and Liquid Fill and Drain Valves* for a Goddard Space Flight Center (GSFC) payload, the Magnetospheric Multiscale (MMS) Mission.

Unless otherwise specified, requirements in this document apply to both types of fill and drain valves.

2.0 APPLICABLE DOCUMENTS

The following documents and drawings in effect on the day this specification was signed **shall** apply to the fabrication and to the mechanical and environmental requirements of the *fill and drain valve* to the extent specified herein. In the event of conflict between this specification and any referenced document, this specification will govern, with the exception of the Magnetospheric Multiscale *Fill and Drain Valve* Statement of Work (461-*PS*-SOW-0*014*), in which case the Statement of Work (SOW) takes precedence.

The following is a list of the applicable specifications and publications.

Table 2-1 Applicable Documents

Section	Document Number	Title	Revision/Date
Many	461-*PS*-SOW-0*014*	MMS *Fill and Drain Valve* Statement of Work	*TBD*
Many	461-*PS*-LIST-0*027*	MMS *Fill and Drain Valve* DILS	*TBD*
Many	AFSPCMAN 91-710	Range Safety User Requirements	07/01/2004
Many	461-SYS-RQMT-0023	MMS Environmental Requirements Specification	
Many	461-PS-PSEC-0035	MMS Propulsion Subsystem Specification	
5.2.3	AS-4395	Fitting End, Flared Tube Connection, Design Standard	2007
6.4.2	NASA-HDBK-7005	Dynamic Environment Criteria	BASE/ 3/13/2001
6.4.2	NASA-STD-7001	Payload Vibroacoustic Test Criteria	BASE/ 6/21/1996
6.11.1	461-SYS-SPEC-0014	MMS Spacecraft Systems Specification	
7.1.1.3	JSC-SN-C0005C	Contamination Control Requirements for the Space Shuttle Program	
7.1.1.2	IEST-STD-CC1246D	Product Cleanliness Levels And Contamination Control Program	2002
7.1.2.2.1	ASTM E-595-07	Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment	12/01/2007
7.1.2.2.2	461-SYS-PLAN-0050	MMS Contamination Control Plan	
8.1.2	MIL-DTL-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys	07/11/2006
8.1.2	AMS 2488	Anodic Treatment - Titanium and Titanium Alloys Solution Ph 13 Or Higher	06/01/2000
8.1.2	MIL-A-8625F(1)	Anodic Coatings for Aluminum and Aluminum Alloys	09/15/2003
8.1.2.1	MIL-PRF-26536E	Performance Specification, Propellant, Hydrazine	09/24/1997
8.1.2.2	JSC-SPEC-C-20	Water, High Purity, Specification for	
8.1.2.2	MIL-PRF-27401D	Performance Specification for Propellant Pressurizing Agent, Nitrogen	10/03/1995
8.1.2.2	FED-STD-TT-I-735A	Clean Room and Work Station Requirements, Controlled Environment	
8.1.2.2	MIL-PRF-27407B	Performance Specification, Propellant Pressurizing Agent, Helium	08/25/1997

8.1.2.2	MIL-PRF-27415A	Performance Specification, Propellant Pressurizing Agent, Argon	12/11/1997
8.1.2.3	MSFC-HDBK-527	Materials Selection List for Space Hardware Systems	09/30/1988
8.1.2.3	MIL-STD-889	Military Standard, Dissimilar Metals	07/07/1976

3.0 CONTRACT DESCRIPTION

3.1 *FILL AND DRAIN VALVE* DESCRIPTION

The *fill and drain valve* is a *valve type of* device that is capable of *filling and draining of the spacecraft fluids, including test fluids, gaseous pressurant, and propellant*. Two types of *fill and drain valves* are needed: a *gas fill and drain valve* and a *liquid fill and drain valve.* There will be four (4) valves of each valve type per spacecraft (SC).

*The fill and drain valves **shall** include caps and seals required to seal the valve both in the closed position and when open with propellant flowing. Additionally, assorted AN fitting threads corresponding to the operational fluids **shall** be used to ensure proper operation.*

All of the written requirements in this document must apply at the end of spacecraft (SC) life, as defined in Section 8.5.1.

3.2 GROUND SUPPORT EQUIPMENT DESCRIPTION

N/A

4.0 FUNCTIONAL/PERFORMANCE REQUIREMENTS

The component **shall** be designed to withstand the operational and non-operational environments specified in the following section without degradation to mission goals and performance requirements.

4.1 *FILL AND DRAIN VALVE* FLIGHT UNIT FUNCTIONAL/PERFORMANCE REQUIREMENTS

4.1.1 Leakage

4.1.1.1 Primary Seat Closed, AN Cap Removed, and External Cover Removed

Each valve **shall** demonstrate a total leakage rate of no greater than 1 x 10^{-6} sccs of GHe at the valve's MEOP with the primary seat closed, AN cap removed, and external cover removed.

Rationale: MMS Leakage Analysis, 461-PS-ANYS-0027

4.1.1.2 Primary Seat Open, AN Cap Installed, and External Cover Removed

Each valve **shall** demonstrate a total leakage rate of no greater than 1 x 10^{-5} sccs of GHe at the valve's MEOP with the primary seat open, AN cap installed, and external cover removed.

Rationale: MMS Leakage Analysis, 461-PS-ANYS-0027

4.1.1.3 Primary Seat Open, AN Cap Removed, and External Cover Installed

Each valve **shall** demonstrate a total leakage rate of no greater than 1 x 10^{-5} sccs of GHe at the valve's MEOP with the primary seat open, AN cap removed, and external cover installed.

Rationale: MMS Leakage Analysis, 461-PS-ANYS-0027

4.1.2 Pressures

4.1.2.1 MEOP

The Maximum Expected Operating Pressure (MEOP) **shall** be 325 psia at 50°C. MEOP is the maximum pressure to which the particular valve is subjected under any operating conditions.

Rationale: Fill and Drain Valves have MEOP of 325 psia

4.1.2.2 Proof Pressure

The proof pressure capability of valves **shall** be at least 788 psia at 50°C. This is a proof factor of 1.5.

Rationale: (MEOP + 200 (Back-relief Pressure)) x 1.5; refer to AFSPCMAN 91-710

4.1.2.3 Burst Pressure

The burst pressure of valves **shall** be at least 1313 psia at 50°C. This is a burst factor of 2.
Rationale: (MEOP + 200 (Back-relief Pressure)) x 2.5; refer to AFSPCMAN 91-710

4.1.2.4 Interface Tube Design Pressures

4.1.2.4.1 Interface Tube Proof Pressure

Valve's interface tube **shall** be capable of withstanding a proof pressure of no less than 788 psia or 1.5 times the valve's MEOP value.

Rationale: (MEOP + 200 (Back-relief Pressure)) x 1.5 for lines and fittings with diameter less than 1.5 in; refer to AFSPCMAN 91-710

4.1.2.4.2 Interface Tube Burst Pressure

Each valve's interface tube **shall** have burst pressure of no less than 2100 psia or 4 times the valve's MEOP value.

Rationale: (MEOP + 200 (Back-relief pressure)) x 4 for lines and fittings with diameter less than 1.5 in; refer to AFSPCMAN 91-710

4.1.3 Pressure Drop

The *liquid fill and drain* valves shall be capable of providing a flow rate of 0.05 kg/s H_2O with a maximum pressure drop of 20 psid. The *gas fill and drain* valves shall be capable of providing a flow rate of 0.0014 m^3/s GHe with a maximum pressure drop of 20 psid.

4.1.4 Sealing

4.1.4.1 Closed Position Seals

Each fill and drain valve seal **shall** contain at least three (3) seals when both the AN cap and external cover are installed.

Rationale: Derived from the MMS Propulsion Subsystem Spec, 461-PS-SPEC-0035

4.1.4.2 Open Position Seals

Each valve **shall** contain at least two (2) seals when the valve is in the open position with propellant flowing.

Rationale: Derived from the MMS Propulsion Subsystem Spec, 461-PS-SPEC-0035

4.1.4.3 Lock Wire Capability

All seals on each fill and drain valve shall contain lock wires to ensure that they remain in place throughout the life of the mission.

Rationale: Derived from the MMS Propulsion Subsystem Spec, 461-PS-SPEC-0035

4.1.5 Opening Design

Each seal **shall** be designed to prevent inadvertent opening.

Rationale: Derived from the MMS Propulsion Subsystem Spec, 461-PS-SPEC-0035

4.1.6 Ease of Operation

Each valve **shall** be designed to be operable by one torque wrench.

Rationale: Derived from the MMS Propulsion Subsystem Spec, 461-PS-SPEC-0035

4.1.7 Cycles

The fill and drain valves **shall** be qualified for at least 150 functional cycles.

Rationale: Derived from the MMS Propulsion Subsystem Spec, 461-PS-SPEC-0035

4.2 RESOURCE ALLOCATIONS

4.2.1 Mass Allocation

The *fill and drain valve* **shall** have a mass of less than or equal to *0.22* kg with all caps.

Rationale: the MMS Propulsion Subsystem mass allocation

4.2.2 Nominal Power Allocation

N/A

4.2.3 Peak Power Allocation

N/A

4.2.4 Deployment Power Allocation

N/A

4.2.5 Telemetry

N/A

4.3 POWER

N/A

4.4 ELECTRICAL GROUNDING

N/A

4.5 SIGNAL AND DATA INTERFACES

N/A

4.6 OPERATING MODES

N/A

4.7 COMMAND AND DATA SERVICES

N/A

4.8 FLIGHT SOFTWARE

N/A

4.9 NEA/EED DESIGN

N/A

5.0 PHYSICAL REQUIREMENTS

5.1 INTERFACE DOCUMENTATION

N/A

5.2 FLUID INTERFACES

5.2.1 Interface Tube Dimension

Each fill and drain valve **shall** have interface tube dimension of 0.25 inch O.D., 0.028 inch wall thickness and 2.5±0.06 inch length for gas or 2.25±0.06 inch length for liquid.

Rationale: By Design

5.2.2 Interface Tube Material

The interface tube of each fill and drain valve **shall** be made out of SS 304L.

Rationale: By Design

5.2.3 AN Fitting

AN fitting sizes of valves **shall** be 0.25” for gas and 0.375” for liquid per AS-4395.

5.3 MASS PROPERTIES

5.3.1 Component Masses

See Section 4.2.1.

5.3.2 Center of Mass Location

See Section 3.1 in the MMS Propulsion *Fill and Drain Valve* SOW, 461-PS-SOW-0014

5.3.3 Center of Mass Accuracy

The center of mass **shall** be determined to within *±1.0 mm* relative to an external reference.

5.3.4 Moments of Inertia

N/A

5.3.5 Products of Inertia

N/A

5.3.6 Determination of Moments and Products of Inertia

N/A

5.4 PHYSICAL ENVELOPE

Each fill and drain valve **shall** have a cylindrical envelope with an outer diameter (OD) of less than 2.0 inches and the total length of less than 6.25 inches. This envelope shall encompass the valve, AN cap, external cover, and mounting surface.

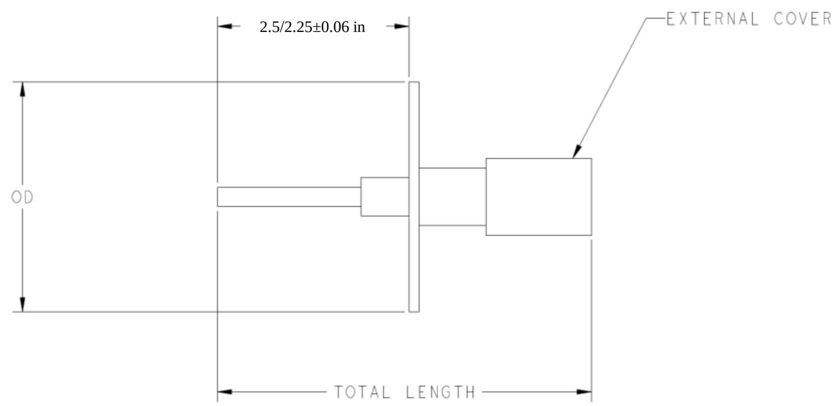

Figure 5-1 Fill and Drain Valve Envelope

Rationale: To allow weld head access and prevent FOV blockage

5.5 MOUNTING

N/A

5.6 FIELDS OF VIEW

N/A

5.7 ALIGNMENT

N/A

6.0 ENVIRONMENTAL REQUIREMENTS

Environmental design requirements for the spacecraft components are specified in this section. The MMS spacecraft components will be capable of meeting their performance requirements after exposure to the environments specified in this section.

All loads and environments in this document are preliminary and may be updated as the MMS spacecraft is defined.

6.1 MECHANICAL FACTORS OF SAFETY

The *fill and drain valve* as well as Mechanical Ground Support Equipment (MGSE) **shall** demonstrate positive Margins of Safety under limit loads for all yield and ultimate failures using the Factors of Safety (FS) defined in Table 6-1 (see NASA-STD-5001A for more information on other materials [e.g. glass]). Margin of Safety (MS) is defined as follows:

MS = (Allowable Stress(or Load)/(Applied Limit Stress(or Load) x FS)) -1

Table 6-1 Factors of Safety

Type of Hardware[1]	Static/Sine	Random/Acoustic
Tested Metallic Structure Yield	1.25	1.6
Tested Metallic Structure Ultimate	1.4	1.8
Stability Ultimate	1.4	1.8
Untested Flight Structure Yield- metallic only	2.0	
Untested Flight Structure Ultimate - metallic only	2.6	

1 – Factors of safety for pressurized systems to be compliant with AFSPCMAN 91-710, "Range Safety User Requirements."
2 – Factors shown should be applied to statistically derived peak response based on RMS level. As a minimum, the peak response **shall** be calculated as a 3-sigma value.

Rationale: MMS Environmental Requirements Document, 461-SYS-RQMT-0023

6.2 QUASI-STATIC ACCELERATION

Quasi-static acceleration represents the combination of steady-state accelerations and the low frequency mechanically transmitted dynamic accelerations that occur during launch.

The *fill and drain valve* **shall** demonstrate its ability to meet its performance requirements after being subjected to the net CG limit loads shown in Table 6-2.

Linear interpolation should be used between breakpoints to determine the appropriate limit load as a function of *the fill and drain valve* weight. Note that these design limit loads are intended to cover only the low frequency launch environment and must be used in conjunction with the random vibration environments to assess structural margins.

Table 6-2 Fill and Drain Valve Limit Loads

Fill and Drain Valve **Mass (kg)**	**Limit Load (g, any direction)**
0.5 or less	35.9

Rationale: MMS Environmental Requirements Document, 461-SYS-RQMT-0023

6.3 FREQUENCY REQUIREMENT

6.3.1 Fundamental Launch Frequencies

The *fill and drain valve* **shall** have a fundamental frequency greater than *75* Hz when hard mounted at its SC interface.

Rationale: MMS Environmental Requirements Document, 461-SYS-RQMT-0023

6.3.2 On-Orbit Frequencies

N/A

6.4 VIBRATION

6.4.1 Sinusoidal Vibration

The *fill and drain valve* **shall** demonstrate its ability to meet its performance requirements after being subjected to the sine vibration environment in Table 6-3, applied at the MMS to *the fill and drain valve* interface. See Section **Error! Reference source not found.** in the MMS Propulsion Fill and Drain Valve SOW, 461-PS-SOW-0014, for definitions of Protoflight, Qual, and Acceptance.

Table 6-3 *Fill and Drain Valve* Sine Vibration Environment

Frequency	**Protoflight/Qual Level**	**Acceptance Level**
5 - 50 Hz	12.5 g's (4 oct/min protoflight and 2 oct/min prototype hardware)	10 g's (4 oct/min)

Levels may be notched to not exceed 1.25 times the design limit load. These levels may be updated as coupled-loads analysis (CLA) data becomes available. *The fill and drain valve* **shall** test for this environment up to 50 Hz and be analyzed from 50 to 100 Hz. Peak levels at the low end of the frequency range (5 – 20 Hz typically) may be ramped up as needed to accommodate shaker table displacement limitations.

Rationale: MMS Environmental Requirements Document, 461-SYS-RQMT-0023

6.4.2 Random Vibration

The *fill and drain valve* **shall** demonstrate its ability to meet its performance requirements after being subjected to the random vibration environment in Table 6-4, applied at the MMS to *the fill and drain valve* interface.

Table 6-4 *Fill and Drain Valve* Random Vibration Environment

Frequency (Hz)	Protoflight/Qual Level	Acceptance Level
20	0.026 g^2/Hz	0.013 g^2/Hz
20 – 50	+6 dB/Octave	+6 dB/Octave
50 – 800	0.160 g^2/Hz	0.080 g^2/Hz
800 – 2000	-6 dB/Octave	-6 dB/Octave
2000	0.026 g^2/Hz	0.013 g^2/Hz
Over All	14.1 grms	10.0 grms
Duration (minutes)	1 (protoflight), 2 (Qual)	1

The highest design loads may be from this random vibration environment. The contractor **shall** perform random vibration analysis along with static loads analysis. Please see NASA-HDBK-7005 and NASA-STD-7001 for more information.

Rationale: MMS Environmental Requirements Document, 461-SYS-RQMT-0023

6.5 SHOCK

The *fill and drain valve* **shall** be designed to meet its performance requirements after being subjected to the shock environment in Table 6-5, applied at the *fill and drain valve* interface.

Table 6-5 Limit Level Shock Response Spectrum

Frequency (Hz)	Acceptance	Proto-flight
100 100 to 800 800 to 3000	*54* g + *8.7* dB/Octave *1080* g	*76* g + *8.7* dB/Octave *1527* g
3000 to 10000 10000	+ *1.4* dB/Octave *1440* g	+ *1.4* dB/Octave *2036* g

Rationale: MMS Environmental Requirements Document, 461-SYS-RQMT-0023

6.6 ACOUSTICS

The *fill and drain valve* **shall** be designed to meet its performance requirements after being subjected to the acoustic environment listed in Table 6-6.

Table 6-6 Limit Level Acoustic Environments

Center Frequency (Hz)	Max Predicted Sound Pressure Level (dB)
25	114.0
31.5	120.3
40	127.5
50	122.5
63	124.0
80	124.5
100	126.0
125	126.0
160	127.1
200	127.0
250	126.5
315	126.0
400	126.0
500	124.5
630	122.0
800	119.5
1000	116.5
1250	114.0
1600	112.0
2000	114.0
2500	111.0
3150	110.0
4000	109.0
5000	108.5
6300	108.0
8000	109.7
10000	110.5
OASPL	137.1
Duration	1 minute flight and 2 minutes non-flight hardware

The reference point is 20 μPa.

Rationale: MMS Environmental Requirements Document, 461-SYS-RQMT-0023

6.7 TRANSPORTATION

All Transportation loads that the *fill and drain valve* is exposed to **shall** be less than the Quasi-Static, Vibration, Shock, and Acoustic loads previously defined.

6.8 PRESSURE

6.8.1 Operating Pressure Range

The *fill and drain valve* **shall** be designed to meet all performance requirements while operating over a pressure range of 1.08×10^5 N/m^2 (813 Torr) to 1.3×10^{-12} N/m^2 (1×10^{-14} Torr).

Rationale: Atmospheric Pressure=813 Torr; Vacuum Pressure=1×10^{-14} Torr

6.8.2 Maximum Depressurization Rate

N/A

6.9 ON-ORBIT DYNAMIC ENVIRONMENT

N/A

6.10 HUMIDITY

The *fill and drain valve* **shall** be able to meet performance requirements after exposure to relative humidity levels of 35% to 100%.

Rationale: MMS Environmental Requirements Document, 461-SYS-RQMT-0023

6.11 THERMAL REQUIREMENTS

6.11.1 Flight Interface Design Temperature Limits

The *fill and drain valve* **shall** be capable of surviving indefinitely when its temperatures are within the survival limits shown in Table 6-7 without damage or permanent performance degradation.

Table 6-7 Temperature Levels at Mounting Interface

	Minimum Temperature (ºC)	Maximum Temperature (ºC)
Operational	+10	+40
Protoflight/Acceptance	+10	+50
Non-Operational[1]	-30	+70

1: Valve not in operation with leakage rate at or better than 10^{-6} scch indefinitely

Rationale: Derived from the MMS S/C Systems Specification, 461-SYS-SPEC-0014

6.11.2 Ground Test Environment

N/A

6.11.3 Allocation of Spacecraft Monitored Temperature Sensors

N/A

6.12 CHARGE PARTICLE RADIATION REQUIREMENTS

N/A

7.0 CLEANLINESS

7.1 SURFACE CONTAMINATION

7.1.1 Surface Contamination Levels At Delivery

7.1.1.1 Particulate Contamination

N/A

7.1.1.2 Molecular Contamination

N/A

7.1.1.3 External Cleanliness

All hardware surfaces **shall** be verified to be "visibly clean, highly sensitive" per JSC-SN-C0005C, prior to deliver to NASA/GSFC. This is accomplished by maintaining all hardware in a double bag for storage.

7.1.1.4 Internal Cleanliness

The propulsion components, lines, and fittings **shall** be cleaned, and verified internally clean, to level 100A per IEST-STD-CC1246 (as modified by the following: no metal particles allowed above 25 µm) prior to integration in the system.

7.1.2 Surface Contamination Generation

7.1.2.1 Particulate Generation

N/A

7.1.2.2 Molecular Generation

7.1.2.2.1 Material Selection

The *fill and drain valve* materials **shall** have a total mass loss (TML) less than 1.00% and a collected volatile condensable mass (CVCM) less than 0.10%, as specified in ASTM E-595 unless a materials usage agreement has been generated and approved by NASA/GSFC. Silicones should be avoided or minimized. It is highly recommended that silicones be baked out at a high temperature prior to integration into the system to prevent extended bakeouts of the entire assembly.

7.1.2.2.2 Assembly Outgassing

When measured in a vacuum of 10E-6 torr at 50 °C, the *fill and drain valve* outgassing **shall** not exceed 2E-10 g/sec per kg of unit under test of mass that is condensable on a Quartz Crystal Monitor (QCM) that is operated at -20 degrees.

Rationale: the MMS Observatory CCP, 461-SYS-PLAN-0050

7.2 ELECTROSTATIC CLEANLINESS

N/A

7.3 MAGNETIC CLEANLINESS

7.3.1 Minimizing Permanent Fields

The *fill and drain valve* **shall** not contain any of the materials described in . Exceptions to this requirement can be made case by case upon completion of the magnetic assessment and the MMS project office approval.

Table 7-1: Prohibited Magnetic Materials List

Alloy 426	Mumetal
Alloy 720[1]	Nichrome
Carbon Steel 1008	Nickel 200, 270
Chromium	Nickel Iron
Cobalt	Pelcoloy
Copperweld	Permalloy
Dumet	Platinum
Electroless Nickel (except high-phosphorous)	Remendur
Electroloy	Rodar
Elinvar	Stainless Steel 202[2]
Fenicoloy	Stainless Steel 302[2]
Ferrites	Stainless Steel 303[2]
Haynes Alloy #6	Stainless Steel 403 & 405
Invar	Stainless Steel 410 & 416
Iron	Stainless Steel 430 & 446
Kovar	Stainless Steel AISI 440C
Mesoloy	Supermalloy
Molypermalllow	Ti 430
Monel K[1]	Vicalloy
Monel R	

[1]Based on a GSFC Materials Engineering Branch Technical Information Paper No. 128 entitled, "Minimizing Stray Magnetic Fields through Materials Selection".

[2]Non-magnetic (technically paramagnetic) in the annealed condition. If any of these alloys are cold worked then they will become magnetic. The alloy condition will be clearly indicated on the Material Certification that will accompany the purchase.

[3]Inconel alloys, 600, 625 and 718, are considered non-magnetic, but become magnetic at cryogenic temperatures.

8.0 DESIGN & CONSTRUCTION REQUIREMENTS

8.1 PARTS, MATERIALS & PROCESSES (PMP)

8.1.1 EEE Parts

N/A

8.1.2 Materials

The *fill and drain valve* contractor's Quality Assurance system for materials **shall** be in accordance with the requirements in the SOW.

Aluminum parts **shall** be finished with iridite per MIL-DTL-5541, Class 3.

Titanium surfaces **shall** be finished per AMS 2488.

Non-mounting surfaces **shall** be coated with a high emissivity coating (>0.7) such as black anodize per MIL-A-8625F Type II, Class 2.

8.1.2.1 Hydrazine Compatibility

The fill and drain valve **shall** function within specification after exposure to hydrazine per MIL-PRF-26536E for forty (40) months.

8.1.2.2 Liquid Exposure Compatibility

The fill and drain valve **shall** be compatible with prolonged exposure to de-ionized water per JSC-SPEC-C-20, Grade A, GN2 per MIL-PRF-27401D, IPA per FED-STD-TT-I-735A, GHe per MIL-PRF-27407B, Grade A, Ar per MIL-PRF-27415A Amendment 1, and Research grade Xenon gas.

8.1.2.3 Metal Part Corrosion

The fill and drain valve **shall** not use metals that are susceptible to corrosion in ground and flight environments per MSFC-HDBK-527F and MIL-STD-889.

8.1.3 Software Assurance

N/A

8.2 ELECTRICAL

N/A

8.3 SAFETY

N/A

8.4 ELECTROMAGNETIC COMPATIBILITY

N/A

8.5 IDENTIFICATION AND MARKING

Each unit **shall** be permanently marked with the part number, flow direction, and a unique sequential serial number in the area designated on the interface control drawing in a manner to be approved by the GSFC COTR.

All markings **shall** use alcohol proof ink or be etched in non-structurally critical areas.

8.6 WORKMANSHIP

See Section 6.6 of MMS Fill and Drain Valves Statement of Work, 461-PS-SOW-0014.

8.7 INTERCHANGEABILITY

The fill and drain valve **shall** be directly interchangeable in form, fit, and function with other items of the same part number.

Rationale: The MMS Propulsion Subsystem Specification, 461-PS-SPEC-0035

8.8 RELIABILITY

8.8.1 Mission Life

The *fill and drain valve* **shall** meet all performance specifications throughout 1 year of ground testing and 28 months of operation in space.

Rationale: The MMS Propulsion Subsystem Specification, 461-PS-SPEC-0035

8.8.2 Shelf Life

The *fill and drain valve* **shall** not suffer any degradation in performance when stored for five (5) years either on the S/C or in bonded storage.

Rationale: The MMS Propulsion Subsystem Specification, 461-PS-SPEC-0035

8.9 GROUND HANDLING

The fill and drain valves **shall** not require an additional component/device for the ground operation.

9.0 LOGISTICS

N/A

10.0 VERIFICATION REQUIREMENTS

N/A

APPENDIX A ABBREVIATIONS AND ACRONYMS

Abbreviation/ Acronym	Definition
Al	Aluminum
CCB	Configuration Control Board
CCR	Configuration Change Request
CG	Center of Gravity
CM	Configuration Management
CMO	Configuration Management Office
COTR	Contracting Officer's Technical Representative
CVCM	Collected Volatile Condensable Mass
DILS	Deliverable Items List and Schedule
EOL	End of Life
FS	Factor of Safety
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
ICD	Interface Control Drawing
I&T	Integration and Test
MEOP	Maximum Expected Operating Pressure
MMS	Magnetospheric Multiscale
MOP	Maximum Operating Pressure
MS	Margin of Safety
NASA	National Aeronautics and Space Administration
OD	Outer Diameter
PDL	Product Design Lead
QCM	Quartz Crystal Monitor
SC	Spacecraft
SCoRe	Signature Controlled Request
SOW	Statement of Work
STP	Solar Terrestrial Probe
TBD	To Be Defined
TBR	To Be Reviewed